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Physical activity behaviour and coronary heart disease mortality among South Asian people in the UK: an observational longitudinal study

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ABSTRACT

Objective The aim of this study was to investigate the contribution of physical inactivity to the excess mortality from coronary heart disease (CHD) observed in the UK South Asian population.

Design An observational longitudinal study with follow-up mortality data from NHS registries.

Setting Data from the Health Survey for England, 1999 and 2004.

Participants 13 293 White and 2120 South Asian participants aged ≥ 35 years consented to the mortality follow-up.

Main outcome measures Deaths from CHD.

Results South Asian participants were more likely to be physically inactive than white participants (47.0% vs 28.1%). Deaths from CHD were more common in UK South Asian participants, particularly among Pakistani and Bangladeshi groups (HR 2.87, 95% CI 1.74 to 4.73), than in UK white participants, and South Asian people experienced an event at an age on average 10 years younger than white people. Physical inactivity explained >20% of the excess CHD mortality in the South Asian sample, even after adjustment for potential confounding variables (including socioeconomic position, smoking, diabetes and existing cardiovascular disease).

Conclusions Physical inactivity makes a significant contribution to the excess CHD mortality observed in the South Asian population in the UK. This highlights the importance of prioritising the promotion of physical activity in this high-risk population.

South Asian populations (people originating from the Indian subcontinent) worldwide have an increased risk of coronary heart disease (CHD) compared with other ethnic groups.^{1 2} This vulnerability has been observed in people residing in South Asia² and in migrant populations elsewhere.^{1 3} Several biological explanations have been proposed—for example, compared with other ethnic groups, South Asian people have higher central adiposity,⁴ increased insulin resistance⁵ and lower high-density lipoprotein cholesterol.⁶ The INTERHEART study found that increased rates of traditional risk factors explained the excess risk of CHD in South Asian groups (from South Asia) compared with other ethnic groups globally.⁷ In contrast, Forouhi *et al* showed that, in a South Asian sample from west London, the increased CHD mortality could not be attributed to conventional CHD risk factors.⁶ Hence, explanations for this excess risk of CHD are not fully understood.

Behavioural risk factors have also been explored. There is significant heterogeneity in smoking rates

between South Asian subgroups, with negligible levels in Indian groups and South Asian women compared with high rates in Pakistani and Bangladeshi men.⁸ Physical inactivity is a major CHD risk factor^{9 10} and relates to primary and secondary prevention of CHD.^{11 12} Recent analyses from the Health Survey for England (HSE) show that physical activity is consistently low in all South Asian groups irrespective of age, sex and subgroup.¹³ Physical inactivity is therefore likely to contribute to the excess CHD mortality observed in UK South Asian people. Physical activity was one of nine potentially modifiable conventional risk factors contributing to high rates of myocardial infarction among South Asian people in the INTERHEART study.⁷ Despite this evidence, few longitudinal studies in Britain have examined physical inactivity as a predictor for CHD mortality in this high-risk population.

The aim of these analyses was to investigate the role of physical activity in explaining the excess CHD mortality observed in UK South Asian subjects compared with UK white subjects using nationally representative longitudinal data. In addition, we wanted to evaluate the relative contribution of physical inactivity to CHD mortality separately in both ethnic groups.

METHODS

The HSE is an annually repeated cross-sectional survey of the general population that began in 1991. All surveys covered the English adult population aged ≥ 16 years living in private households. HSE samples are selected using a multistage stratified probability design to give representative samples of the target population. Stratification is based on geographical entities (postcode sectors selected at the first stage and household addresses selected at the second stage). Further details on sample design and selection have been published elsewhere.¹⁴ These analyses combined 1999 and 2004 HSE datasets including people aged ≥ 35 years. The surveys focused on cardiovascular disease (CVD) and related risk factors for adults. In addition, in 1999 and 2004, minority ethnic groups were oversampled to boost the sample size of ethnic minorities living in English households. The response rates ranged from 69% to 76% for different survey years.

Procedures and measures

Survey interviewers visited eligible households and collected data on demographics (eg, country of birth), anthropometry (height, weight, waist and

hip circumference), health behaviours (smoking and physical activity) and medical history. All survey materials were translated into Urdu, Punjabi, Gujarati, Hindi and Bengali by an external company using independent proof reading and stringent verification procedures. Interviewers who spoke and read these languages (as well as English) were recruited and received full training. Ethnicity was categorised by the subject's family origins and country of birth (only South Asian participants originating from India, Pakistan and Bangladesh and white British were included). Hypertension, diabetes and existing CVD were identified by questions about longstanding illnesses. Self-reported health was also measured. Detailed information on the survey method can be found elsewhere.^{12 15}

Socioeconomic position (SEP) was assessed using highest educational qualifications, Registrar General occupational status and total equivalised (adjusted for household size) household income.

Frequency of leisure time physical activities in the 4 weeks prior to the interview were assessed using multiple questions across three domains of activity: leisure time sports/exercises (eg, cycling, sports); domestic activities (heavy housework, heavy 'do-it-yourself', gardening, heavy manual); and walking for any purpose. This measure was classified as weekly occasions of physical activity of at least moderate intensity and for a minimum of 30 min. Owing to the large proportion of participants reporting no weekly activity (approximately 30%), a binary variable was created which identified those people performing some physical activity (of at least moderate intensity for a minimum of 30 min/week) compared with those reporting none. The validity of the physical activity questionnaire is supported by objective measures of activity using accelerometry devices in 106 British adults from the general population.¹⁶ In addition, these activity measures have previously been related to incident CVD events and risk markers,^{17 18} providing evidence of convergent validity.

CHD MORTALITY DATA

The 1999 and 2004 surveys were linked to NHS Central Register mortality data up to March 2008. All deaths are required to be registered with the local authority within 5 days of occurrence in England. Diagnoses for CHD cause of death were identified according to the 9th and 10th International Classification of Diseases codes (ICD-9 410–414 and ICD-10 I20–I25). These analyses include only participants who consented to mortality follow-up (48%) and for whom complete data were available (13 293 white, 1244 Indian and 876 Pakistani/Bangladeshi participants).

Statistical analyses

South Asian subgroups were divided by country of birth to identify heterogeneity between groups, as previously observed^{8 19}; Indian participants were classified separately, and Pakistani and Bangladeshi participants were amalgamated (based on initial analyses of CHD rates and risk factor profiles and using classifications employed previously).^{19 20} To compare baseline characteristics between those who consented and those who did not consent and between South Asian and white groups, independent sample *t* tests were performed for continuous variables and χ^2 tests for categorical variables. Having ascertained that the proportional hazards assumption had not been violated, Cox proportional hazards models were used with months as the time scale to estimate the risk of CHD mortality in relation to ethnicity. For participants with no event recorded,

the data were censored at March 2008. Age- and sex-adjusted HRs were attained to identify independent predictors of CHD mortality; these were performed separately by ethnic group (Indian, Pakistani and Bangladeshi people were grouped together to accommodate sample size limitations for these analyses). In addition, these analyses were repeated in the full sample with the inclusion of ethnicity and ethnicity $\times$ risk factor interactions, testing whether the risk factors affected CHD mortality in similar ways across groups. Cox models then identified the contribution of ethnicity to the risk of CHD mortality (model 1). Model 2 shows the variance explained by potential moderating/confounding variables, smoking, SEP (education and occupational grade), diabetes and existing CVD without physical activity. In a fully adjusted model (model 3), physical activity was included to establish the additional contribution of physical activity to ethnic group differences in CHD mortality. The formula used to calculate the percentage of the variance explained by the variables in the model was $(\text{HR}_{\text{basic model}} - \text{HR}_{\text{adjusted}}) / (\text{HR}_{\text{basic model}} - 1) \times 100$.²¹ All analyses were performed using SPSS 14.0.

RESULTS

Significant differences were found between those who did and did not consent to mortality follow-up. Those who refused follow-up were more likely to be younger ($p < 0.001$), male ($p < 0.001$), of South Asian origin ($p < 0.001$) and to have lower levels of education ($p < 0.001$). In addition, they had an increased risk of hypertension ($p < 0.001$) and existing CVD ($p < 0.001$), but had lower adiposity ($p < 0.001$) and were less likely to smoke ($p = 0.007$). These results suggest a mixed risk profile between consenters and non-consenters.

Table 1 shows the unadjusted baseline characteristics of white, Indian and Pakistani/Bangladeshi participants. South Asian people were younger with a higher proportion of men. They had a smaller body mass index (BMI) but a higher waist-hip ratio. South Asian participants in general had more adverse health profiles, reporting higher rates of diabetes and poorer subjective health. The Indian participants reported lower levels of existing CVD and the Pakistani/Bangladeshi participants reported significantly higher levels of existing CVD than white respondents. Smoking rates were significantly lower in Indian participants compared with other groups, and physical inactivity was more common in all South Asian subgroups than in the white participants. Education and income were higher among Indian participants but lower in Pakistani/Bangladeshi participants than in white people, but white participants were less likely to work in manual occupations than all South Asian groups.

Figure 1 shows differences in CHD survival rates between white, Indian and Pakistani/Bangladeshi participants. Of the 15 412 participants who consented to mortality follow-up with complete data, 419 died from cardiovascular causes (228 from CHD, 98 from stroke and 93 from other cardiovascular causes) over an average follow-up period of 6.0 years (range 0–10.5). UK South Asian people showed an increased risk of dying from CHD compared with white people. Although the risk was not significantly increased among Indian participants (HR 1.44, 95% CI 0.82 to 2.55), it was significantly higher in the Pakistani/Bangladeshi group (HR 1.87, 95% CI 1.74 to 4.73). There were no significant differences between ethnic groups in the risk of stroke mortality (HR 1.04, 95% CI 0.44 to 2.43).

In unadjusted ethnic group comparisons of those who died from CHD, South Asian participants were significantly younger

Table 1 Comparison of baseline characteristics between white and South Asian groups (n=15 413 unless stated otherwise)

	White (n=13 293)	Indian (n=1244)	p Value	Pakistani/ Bangladeshi (n=876)	p Value
Age (years)	56.3±14.1	49.3±11.1	<0.001	48.5±11.4	<0.001
Sex (% male)	44.4% (n=5901)	52.8% (n=657)	<0.001	79.8% (n=699)	<0.001
BMI (kg/m ²) (n=13 615)	27.5±4.9	26.8±4.3	<0.001	26.6±4.3	0.011
Waist-hip ratio (n=2659)					
Men	0.93±0.06	0.95±0.06	<0.001	0.95±0.06	<0.001
Women	0.81±0.08	0.83±0.06	<0.001	0.85±0.07	<0.001
Hypertension	8.3% (n=1103)	8.8% (n=109)	0.85	10.0% (n=88)	0.015
Diabetes	4.5% (n=598)	8.1% (n=101)	<0.001	14.3% (n=125)	<0.001
Self-reported health (% good/very good)	71.1% (n=9451)	64.0% (n=796)	<0.001	49.3% (n=432)	<0.001
Existing CVD	8.4% (n=1117)	5.2% (n=65)	<0.001	10.7% (n=94)	0.01
Smoking (%)					
Never smoked	39.4% (n=5235)	75.2% (n=935)	<0.001	53.1% (n=465)	0.06
Current smoker	21.8% (n=2903)	12.6% (n=158)		30.5% (n=267)	
Physical activity (weekly)					
None	28.1% (n=3735)	37.1% (n=462)	<0.001	56.7% (n=497)	<0.001
Some	71.9% (n=9558)	62.9% (n=782)		43.3% (n=379)	
Education (% >GCSE)	34.3% (n=4566)	45.8% (n=569)	<0.001	26.3% (n=230)	<0.001
Occupation (% non-manual)	63.6% (n=8448)	55.8% (n=693)	<0.001	48.9% (n=426)	<0.001
Total household income (% >£18 200) (n=12 848)	54.0% (n=6060)	58.6% (n=553)	0.007	27.3% (n=186)	<0.001

Data presented as unadjusted means with standard deviations or percentages (n). Physical activity measure indicates average number of occasions per week of at least a moderate level of activity for ≥30 min. p values indicate group differences, with white group as the reference group. BMI, body mass index; CVD, cardiovascular disease.

than the white sample; Pakistani/Bangladeshi participants died at an age >10 years younger than white participants. All South Asian participants who died from CHD were born outside Britain while 93% of white people were born in Britain. Compared with the white participants, South Asian people who died from CHD were more likely to be male, have lower adiposity (BMI) and to have diabetes. In addition, South Asian subgroups reported poorer subjective health status and significantly lower levels of physical activity. The levels of smoking in women were too low to be examined, but smoking rates were particularly high in Bangladeshi and white men (although small

numbers mean these results should be treated with caution). These results are shown in Appendix 1 in the online supplement. Waist-hip ratio was not used in further analyses because there were considerable missing data and it is likely that it may have acted as a mediator in the relationship between physical activity and CHD mortality.

Independent predictors of CHD mortality

To determine which risk factors to include as covariates in the adjusted models, Cox models tested white and South Asian participants separately (small sample sizes precluded the division of the South Asian sample into subgroups for these analyses). All the covariates showed a similar magnitude of effect and displayed the same direction across ethnic groups, although a number of the associations did not reach conventional levels of significance among South Asian participants, most likely because of the substantially reduced numbers. Ethnicity × risk factor interactions were tested; the only significant interaction observed was between BMI and ethnicity, indicating that BMI was related to CHD mortality in differing ways between ethnic groups. Increasing age and male sex were associated with an increased risk of CHD mortality in this sample. In addition, smoking, diabetes, existing heart disease and lower SEP predicted an increased risk of dying from CHD after adjustment for age and sex. Physical activity was a significant predictor of CHD mortality in both white and South Asian participants, demonstrating a similar level of protection across both groups. BMI and hypertension were not significant predictors in either group, and there were considerable missing data for BMI and income so these variables were not entered in the adjusted models (table 2).

Ethnicity and CHD mortality

Model 1 (controlling for age and sex) shows that Pakistani and Bangladeshi participants were nearly three times more likely to die from CHD than white participants. Indian people in this sample also showed an increased risk but this was non-significant. When physical activity was added without the covariates (results not shown), the effect of ethnicity on CHD mortality

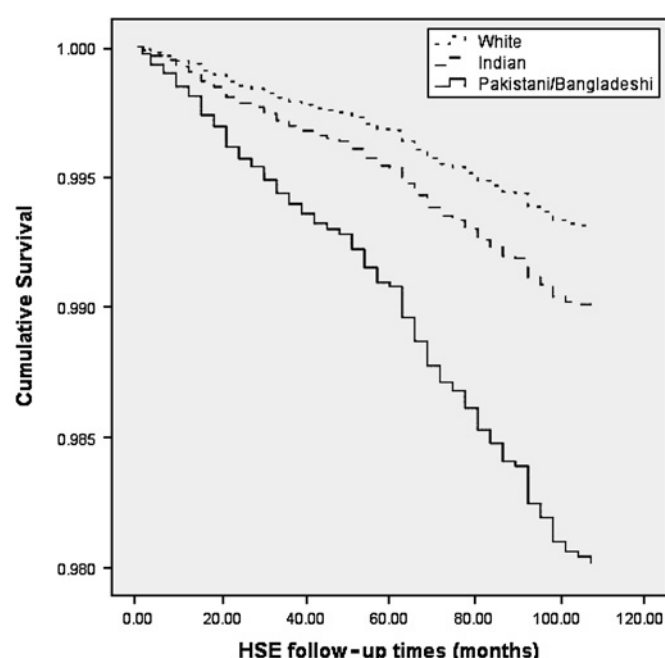


Figure 1 Survival plot for coronary heart disease for white and South Asian groups. HSE, Health Survey for England.

Table 2 HRs (with 95% CIs) for independent predictors of coronary heart disease mortality

	White	South Asian	Ethnicity interaction p Value
Age (years)	1.12 (1.11 to 1.14)	1.11 (1.08 to 1.15)	0.30
Female sex	0.53 (0.40 to 0.70)	0.50 (0.19 to 1.31)	0.16
BMI (kg/m ²)*	1.06 (0.73 to 1.54)	0.53 (0.22 to 1.28)	0.02
Hypertension	1.35 (0.90 to 2.03)	1.15 (0.44 to 3.00)	0.61
Diabetes	1.95 (1.30 to 2.92)	2.34 (1.12 to 4.87)	0.60
Existing cardiovascular disease	2.16 (1.58 to 2.94)	2.34 (1.08 to 5.08)	0.90
Current smoking	1.95 (1.33 to 2.86)	1.95 (0.92 to 4.15)	0.78
Physical activity (weekly)	0.48 (0.34 to 0.66)	0.29 (0.11 to 0.78)	0.79
Education (>GCSE level)	0.62 (0.40 to 0.97)	0.52 (0.20 to 1.37)	0.60
Income (>£18 200)*	0.63 (0.41 to 0.99)	0.74 (0.23 to 2.38)	0.22
Occupation (ref=manual/long-term unemployed)			
Non-manual	0.58 (0.41 to 0.82)	0.51 (0.20 to 1.27)	
Professional/managerial	0.53 (0.34 to 0.82)	0.79 (0.27 to 2.33)	0.46

Adjusted for age and sex. Ethnicity × risk factor interactions performed using models including both South Asian and white participants.

*Missing data (1945 missing BMI values, 2822 missing income values). BMI, body mass index.

was reduced (HR 2.11, 95% CI 1.27 to 3.52) with activity levels explaining 41% of the excess CHD mortality risk in Pakistani/Bangladeshi participants. A similar attenuation of the excess risk in the Indian sample occurred after the inclusion of physical activity. Model 2 shows the variance explained by the moderating/confounding variables smoking, education, occupational grade, diabetes and existing CVD. Once again, the excess risk observed among Pakistani and Bangladeshi participants was reduced by these covariates by approximately 40%. The attenuation was much smaller among Indian participants, with low levels of smoking in this group eradicating the effects explained by the other covariates. Finally, physical activity was included in the fully adjusted model and explained an additional 21% of the increased risk of CHD mortality in the Pakistani/Bangladeshi sample, reducing the difference between ethnic groups almost to non-significance. Although non-significant, 39% of the variance in the difference in CHD mortality between Indian and white participants was explained by physical activity. Owing to the small number of women who died from CHD in the Indian and Pakistani/Bangladeshi groups, these results were repeated in the men only and the same patterns of risk across the ethnic groups were observed (table 3).

DISCUSSION

This study examined the role of physical activity in explaining the excess risk of CHD mortality in a UK South Asian population in comparison with a UK white population. Using

Table 3 Adjusted HRs (with 95% CIs) for ethnicity on coronary heart disease mortality

	White	Indian	Pakistani/ Bangladeshi
Events/n	195/13293	13/1244	20/876
Model 1	1.00	1.44 (0.82 to 2.55)	2.87 (1.74 to 4.73)
Model 2	1.00	1.43 (0.80 to 2.57)	2.12 (1.26 to 3.57)
Total explained (%)		2%	40%
Model 3	1.00	1.26 (0.70 to 2.27)	1.72 (1.02 to 2.92)
Total explained (%)		41%	61%

Only those participants with complete data included in models: white n=13 293; Indian n=1244; Pakistani/Bangladeshi n=876.

Model 1 adjusted for age, sex and ethnicity.

Model 2 adjusted for age, sex, ethnicity and confounding variables (smoking, socioeconomic position, diabetes and existing cardiovascular disease).

Model 3 adjusted for age, sex, ethnicity, confounding variables and physical activity.

longitudinal data from a nationally representative sample of the English population, we have shown that physical inactivity is associated with death from CHD in white and South Asian people.

In corroboration with previous research,¹ we found that the South Asian sample in this study—and in particular the Pakistani and Bangladeshi participants—had an increased risk of dying from CHD compared with white participants. Our results showed that differences in leisure time physical activity explain a substantial proportion of the excess CHD mortality in these groups, even after adjustment for potential moderating or confounding variables. Since physical activity levels are particularly low among UK South Asian groups,¹³ this is an important finding with considerable public health implications.

Regular physical activity acts through numerous pathways to reduce the risk of CVD. These mechanisms include reduced adiposity, improved lipid and glucose profiles, reduced blood pressure and improved endothelial function and immune function.^{9 10 22} Previous research into physical activity and the risk of CHD mortality has predominantly been conducted in westernised white cohorts^{23–26} and there has been little research exploring this association across ethnic groups. In a case-control study of patients with acute myocardial infarction in India, participants undertaking 30 min/day brisk walking had a 55% reduction in risk compared with those who did not exercise.²⁷ Forouhi *et al* used data from a sample from west London to examine the impact of a range of conventional CHD risk factors on mortality.⁶ Self-reported physical activity was included in the multivariate analyses but made little impact on the increased risk of CHD observed among South Asian participants. This might be explained by their inclusion of biochemical and haemodynamic risk factors in the models that could have mediated the relationship between activity and CHD, therefore accounting for some of the variance that would otherwise have been attributed to physical activity. In our analyses, we did not include variables that may have acted as mediators between physical activity and CHD in order to observe the full variance explained by physical activity. Diabetes was included in these analyses because, although it may act as a mediating factor in the relationship between physical activity and CHD mortality, the presence of diabetes could also moderate this relationship. The INTERHEART study also included physical activity in the examination of CHD risk factors in people living in South Asia.⁷ Their results found that South Asian patients with myocardial infarction and controls were more physically inactive than other ethnic groups and that the population-attributable risk for physical inactivity in South Asian people was comparable to other major CHD risk factors. This study, however, did not examine UK South Asian people or other migrant South Asian groups whose activity profiles and environmental context may be significantly different.

Although the increased CHD mortality risk was higher in all South Asian subgroups, it was only significant in Pakistani and Bangladeshi groups. This may be the result of small sample sizes, but previous research has shown that Pakistani and Bangladeshi groups have a higher risk of CHD than Indian people in Britain.¹⁸ Physical activity rates also vary by South Asian subgroup,¹³ making it essential to explore subgroup heterogeneity adequately. Ideally, Pakistani and Bangladeshi participants would also have been examined separately, but low numbers of CHD mortality prevented this. This categorisation has been used previously^{19 20} and, in this sample, the two groups reported very similar CHD risk factor profiles.

We also showed that physical inactivity contributes to CHD mortality to a similar extent in South Asian and white groups, although the small numbers in these ethnically-stratified analyses mean that these results should be treated with caution.

This paper uses nationally representative longitudinal data from across England, making the findings generalisable. Despite this, some limitations should be considered. Selection bias may have been operating between those people who consented to follow-up and those who did not. There was a strong ethnic group difference in consenting behaviour, with South Asian people significantly less likely to provide consent than white people. There was, however, no consistent pattern of increased CHD risk in those who did and those who did not consent in either ethnic group—that is, those who did not consent were more likely to have existing CVD and hypertension but reported lower BMI and were less likely to smoke. Physical activity measures were self-reported and therefore might contain considerable measurement error, and they have not been specifically validated in a South Asian population. However, the validity of the physical activity questionnaire is supported by objective measures of activity¹⁶ and, in addition, these activity data relate to heart rate and adiposity in the same way across the ethnic groups, providing convergent validity.¹³ Unfortunately, no previous work has explored this issue in South Asian populations. Furthermore, the sample of patients who died from CHD was small, so the conclusions of this study should be verified by datasets with larger CHD mortality samples and with objective accelerometry data (currently emerging in population-based samples).²⁸ We were unable to determine a dose-response relationship between physical activity and death from CHD or to identify optimal levels of physical activity for protection against CHD from our analyses; the measure accounts for all weekly moderate to vigorous leisure time activity. Owing to high levels of missing data, physiological measures could not be included in the risk factor models. Finally, since this study was observational, we can only identify associations but causal relationships cannot be confirmed.

These findings provide further evidence for the contribution of physical inactivity to the excess CHD mortality risk observed in UK South Asian groups and should encourage a priority focus of resources towards the facilitation and promotion of physical activity in this high-risk population.

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Competing interests None declared.

Ethics approval This study was conducted with the approval of the North Thames Multi-Centre research ethics committee and the participants gave fully informed consent to participate.

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